

RD Instruments StreamPro ADCP Test Plan

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INTRODUCTION

RD Instruments (RDI) has introduced a new ADCP for shallow water discharge measurements called StreamPro. The StreamPro is designed to make a “moving boat” discharge measurement in streams with depths between 0.5 and 6 feet. If the StreamPro can work reliably in these conditions, it will allow for use of ADCPs in a much greater number of streams than previously possible.

Thorough testing of the StreamPro is needed. This includes testing of the software, hardware, and the resulting discharges. The development and implementation of this test plan **does not** mean that StreamPro equipment cannot be used, however, during the use of the equipment the user should be careful to look for potential problems and, if possible, collect data and make comparisons that can be shared with the Office of Surface Water to help validate the current firmware and software releases.

STREAMPRO SOFTWARE

The StreamPro uses new configuration and data collection software that runs on a handheld PC. This software uses a different file format for storing configuration information than previous RD Instruments ADCPs. Many different types of comparisons will be needed to fully verify the function of the StreamPro software.

1. **Instrument Setup and Data Collection.** The software needs to be used to setup and collect data in the field. This test may be combined with the comparison measurement test defined below. Document any problems, bugs, or suggestions for improving the user interface.
2. **Post Processing Data.** Data collected with the StreamPro can be processed and reviewed with WinRiver Software. When playing back data in WinRiver the configuration file must be converted to the WinRiver configuration format using the StreamPro Configuration File Utility (INI2XML). Document any problems, or bugs encountered processing and reviewing StreamPro data in WinRiver.

DISCHARGE COMPARISON MEASUREMENTS

Comparing measurements of discharge to an absolute standard are not easily accomplished. However, for many years the USGS standard has been a Price AA or Pygmy meter measurement made in accordance with the standards defined in Water-Supply Paper 2175. Due to unsteady flow a direct comparison may not always be possible. Therefore we will define four types of comparisons that could be made in descending order of confidence. Persons making comparison measurements must provide all the documentation to support the comparison with your submission of comparison

data. All data must be collected using standard procedures defined in the attached document.

The table below defines conditions where measurements are needed. For each condition multiple bed types are desirable, including: gravel or smoother, rough bottom (cobble, boulders), and soft bottom (mud, silt, organics).

Condition	Water Velocity (ft/sec)	Water Depth (ft)	Water Mode (ft)	Cell Size (ft)
1	< 0.5	< 1	default (WM12)	0.07
2	< 0.5	1 - 3	default (WM12)	0.16
3	< 0.5	>3	default (WM12)	0.33
6	0.5 - 1.5	< 1	default (WM12)	0.07
7	0.5 - 1.5	1 - 3	default (WM12)	0.16
8	0.5 - 1.5	>3	default (WM12)	0.33
11	>1.5	< 1	default (WM12)	0.07
12	>1.5	1 - 3	default (WM12)	0.16
13	>1.5	>3	default (WM12)	0.33

1. **Comparison to simultaneous cup meter measurement.** The most defensible comparison is made when the discharge is measured simultaneously with both a cup meter and a StreamPro ADCP. To minimize the effects of unsteady flow the cup meter and StreamPro measurements should start and stop at the same time. This may mean that many more than 4 StreamPro transects are collected. The comparison discharge should be based on the average of all StreamPro transects collected during the cup meter measurement.
2. **Comparison to simultaneous FlowTracker measurement.** A SonTek FlowTracker ADV may be used for comparison if the FlowTracker has had some comparison data to a cup meter or rating to provide confidence in its measurements. To minimize the effects of unsteady flow the cup meter and StreamPro measurements should start and stop at the same time. This may mean that many more than 4 StreamPro transects are collected. The comparison discharge should be based on the average of all StreamPro transects collected during the cup meter measurement.

- 3. Comparison to a rating curve.** At locations where it can be demonstrated that the rating curve is accurate and does not change significantly, measurements can be compared to the rated discharge. For this situation, it is recommended that the rating curve be verified twice on the day of the comparison, once at the beginning of the comparison period and once at the end. Verification can be by a standard cup meter measurement or another accepted measurement technique. Individual comparison measurements can contain as few as four transects that fall within 5 percent of the mean of those 4 transects. By collecting more transects, statistics on the variability of a particular configuration can be computed more accurately.
- 4. Comparison to other simultaneous acoustic measurements.** Where another instrument for measuring discharge can be used concurrently, these can be compared to the results using a StreamPro. These other instruments should already have adequate comparison data to a cup meter or rating to provide confidence in their measurements. Positional and other sources of bias should be evaluated to ensure that any differences in discharge are attributed to the difference in instruments not in how they were deployed. Individual comparison measurements can contain as few as four transects that fall within 5 percent of the mean of those 4 transects. By collecting more transects, statistics on the variability of a particular configuration can be computed more accurately.

BOTTOM TRACK EVALUATION

The objective of these bottom track tests are to verify the accuracy of the bottom tracking algorithms and to determine the limiting conditions in which they can be used. You must provide all the documentation to support the comparison with your submission of comparison data. All discharge data must be collected using standard procedures defined in the attached document.

- 1. Evaluation of bottom track limitations.** Sites with various bed material types and bank slopes are needed to fully evaluate the bottom modes (see table below). The objective is to determine the shallowest depths and maximum bottom variability for which bottom tracking will work. When testing on a slope, tests should be made moving up the slope and down the slope to determine the shallowest depth at which it can bottom track in each direction. It is possible that the instrument may track into shallower depths when coming from a deeper depth than when initialized in a shallow depth. The test should be conducted so that both the minimum depth that the instrument will track into and the minimum depth at which tracking is initialized is evaluated. The tester should start and stop the tests in the same location so that bottom track comparison can be made. Tracks should also be made into deep enough water that the bottom tracking will fail. This will identify the maximum expected range for the bottom tracking, for those site conditions.

Stationary test. The ADCP has random noise associated with bottom tracking, therefore, an instrument held in a fixed location will show small random movements based on bottom tracking. This test evaluates the random noise in the bottom tracking algorithms. This test should also be completed with different bed conditions (see table below). To complete this test, the instrument must be deployed in a fixed location. This could be a temporary mount on some fixed platform. All parts of the mount that are in the water should be at least one water depth away from the transducer to avoid sidelobe contamination of the bottom track data. It could be securely anchored. It is important to document the deployment and how much actual movement the deployment may have experienced. This test like a moving bed test should be conducted for no less than 10 minutes. Duration of 30-60 minutes would be preferred. Assuming the instrument did not move, the values to be compared would be the mean velocity computed from the ADCP and the standard deviation associated with the mean.

PITCH AND ROLE EVALUATION

Other acoustic profilers used by the USGS contain pitch/roll sensors to compensate for tilting of the instrument during data collection. Because the StreamPro isn't equipped pitch/roll sensors, evaluation of changing pitch and role during data collection is needed to determine the impact on the discharge measurement quality.

When performing discharge comparison measurements or bottom track evaluations, the following additional data will help evaluate of effect of pitch and role:

1. Collect data in the same location and intentionally rock and twist the StreamPro platform.

Deliberately yawing, pitching, or rolling at rates greater than 3 degrees/second during data acquisition may cause a velocity bias. This is because the StreamPro uses Water mode 12 which is averaging in the phase plane rather than in velocity space.

2. Collect data at the same location with a consistent bias in pitch or roll. Please make note of the angle of pitch or roll applied. This is most easily done by adding a weight onto the StreamPro float to create a fixed pitch or roll.

The table below outlines tests that will help evaluate the capabilities and robustness of the bottom tracking in the StreamPro. No priority has been assigned to the tests and hopefully contributions from various users in different parts of the country will allow us to cover the full range of conditions.

Test No.	Type	Depth	Bed Material	Terrain Variability or Slope
1	Bottom Track Capability and Stationary Tests	< 1 ft	Mud / Silt	Mild Slope
2			Mud / Silt	Steep Slope
3			Sand	Mild Slope
4			Sand	Steep Slope
5			Gravel	Mild Slope
6			Gravel	Steep Slope
7			Cobble/Boulders	Mild Slope
8			Cobble/Boulders	Steep Slope
9		Any	Mud / Silt	Smooth
10			Sand	Smooth
11			Sand	Dunes, Moderate changes
12			Gravel	Moderate changes
13			Gravel	Rapid changes
14			Cobble/Boulders	Moderate changes
15			Cobble/Boulders	Rapid changes
16			Any	Wood debris on bottom

SITE CONDITIONS

The site conditions should be completely documented, for completeness and to facilitate use of these data by others. Video or digital pictures are encouraged. The flow, bed conditions, weather, mounts, boats, and other equipment should be documented. If necessary use a tape recorder to ensure detailed notes and then transcribe them back in the office.

SUBMITTING DATA

Data submitted for the comparisons described herein should be sent via FedEx or a note to msrehmel@usgs.gov with information as where the data can be downloaded. This submission should include all raw data, supporting information used to make the comparison, documentation of any deviation from standard procedures, and documentation of site conditions. Please do not email large data sets without prior notification and approval.

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Standard Procedures for Collection of Discharge Data

- Follow all OSW recommended procedures for making a discharge measurement except as noted in test plan.
- Use standard USGS Acoustic Profiler Discharge Measurement Notes (Form 9-275-I), if possible.
- Use StreamPro Software Version X.XX or greater to collect data and WinRiver 10.06 to post-process
- If possible, collect 12 transects to get a better estimate of the instrument / river variability and to allow evaluation of 2, 4, 6, and 8 transect averages.
- Record air temperature and water temperature
- Document speed and direction of wind.
- Set time on PocketPC and StreamPro
- Run the self-test prior to measurements.
- Configure the StreamPro using built-in automatic bin size computations or minimum bin sizes.
- A simple formula to select a bin size is:

$$\text{Bin size} = \text{Integer}((\text{maximum depth}) / 15)$$

This will give better setups to reduce top layer extrapolation than the automatic bin size computation in the released version of StreamPro software.

- Accurately measure draft.
- Locate a section with uniform flow, if possible.
- Document any observed reverse flow at the edges.
- Set starting and stopping edge to allow two good depth cells at each edge. If this is not possible, document why.
- Collect at least 2 profiles in a stationary position at the beginning and end of each transect.
- Use some kind of fixed reference mark to ensure consistent starting and stopping points, if possible. Measure distance to shore from each reference mark.
- Using a pulley system makes this process much easier and more reproducible, particularly where many measurements will be done.
- Always *measure* distance to shore for each transect, if fixed reference marks are not used.
- Maintain a boat speed equal to or less than the water speed, if at all practical. Document reasons for deviation.
- Use a boat speed which obtains transects in no less than three minutes.

- Make comparison measurements concurrently. Synchronize the beginning and ending times of the StreamPro transects with the other equipment used for the discharge comparison measurements.
- When possible, collect at least one and preferably 2 cup meter measurements. Where there is changing flow conditions, it will be important to identify which transects were collected during the cup meter measurement.